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From Engineer-To-Order to Mass Customization

Anders Haug, Klaes Ladeby, Kasper Edwards

Abstract

Purpose - Most mass customization literature focuses on the move from mass production to mass customization. However, in some literature Engineer-To-Order (ETO) companies are also claimed to have become mass customizers, although it can be questioned if these companies conform to popular definitions of mass customizers. This raises the question: Under which conditions is it reasonable to label ETO companies as mass customizers?

Design/methodology/approach - First, definitions of mass customisation are examined and related to ETO companies that move towards mass customization. Second, the individual transitions from mass production and ETO to mass customization are analyzed by: (i) Relating the transition to classifications from relevant literature, (ii) describing the motivations and risks associated with the transition, and (iii) defining some of the most important transition characteristics. Finally it is discussed if ETO companies can become mass customizers and under which conditions it would be reasonable to describe them as such.

Findings - The paper argues that it from several angles makes sense to label some ETO companies as mass customizers although the products are not at prices near mass produced ones.

Research limitations/implications - To avoid dilution of the concept of mass customization, while not excluding ETO companies, it is suggested to start out with a broad definition of mass customization under which separate definitions of different kinds of mass customizers are created.

What is original/value of paper - Although much has been written about mass customization, and ETO companies in much literature have been labelled as mass customizers, the essential discussion of under which conditions it is reasonable to label ETO companies as mass customizers has been missing.

Keywords - Mass customization, personalization, customer co-design

Paper type - Viewpoint

Introduction

The term "mass customization" was coined by Davis in the book "Future perfect" from 1987 (Davis, 1987). The general perception of mass customization is to offer customers customized products (goods and services) at prices close to the ones of mass production. The increasing demand for customized products could make it seem that mass customization would be a logical step from mass production for many companies. However, according to some researchers, mass customization has not yet had the impact that many had expected, and it is still much of a niche business (Piller and Ihl, 2002; Zipkin, 2001; Piller, 2004).

Most mass customization literature focuses on cases where companies move from mass production to mass customization, and as a consequence the definitions of mass customization are somewhat one-sided, focusing only on this kind of transition. In some literature also other types of companies are claimed to have become mass customizers (e.g. Pine et al., 1995; Duray, 2002; Hvam, 2006; Petersen and Jørgensen, 2005; Steger-Jensen and Svensson, 2004). However, it can be questioned if these companies conform to popular definitions of mass customizers, such as being able to offer products at prices close to mass produced products. In this paper we focus on engineering companies who per definition delivers products which are engineered to the specific requirements of the customer, referred to as Engineer-To-Order (ETO) companies. Therefore, two important questions need to be answered: First, what are the differences in the transition characteristics when mass producers and ETO companies move towards mass customization? Second, is it reasonable to label ETO as mass customizers and subsequently under which conditions would this be appropriate?

The paper describes some of the major differences between mass production and ETO companies in their transition towards mass customization, and concludes that it is reasonable to label some ETO companies as mass customizers although the end-products are not at prices near mass produced ones, as many popular definitions of mass customization require. To avoid dilution of the concept of mass customization while not excluding ETO companies it is suggested to start out with a broad definition of mass customization under which more specific definitions of different kinds of mass customizers are created.

The Customer Order Decoupling Point

The concept of customer order de-coupling point (CODP) provides a way of differentiating between manufacturing approaches. The CODP defines where in the manufacturing process a product is linked to a customer order. Sometimes the CODP is referred to as the order penetration point (e.g. Olhager, 2003). A literature-review by Wikner and Rudberg (2001) shows that four CODPs are most frequently applied, namely: Engineer-To-Order (ETO), Make-To-Order (MTO), Assemble-To-Order (ATO), and Make-To-Stock (MTS). These are shown in figure 1.

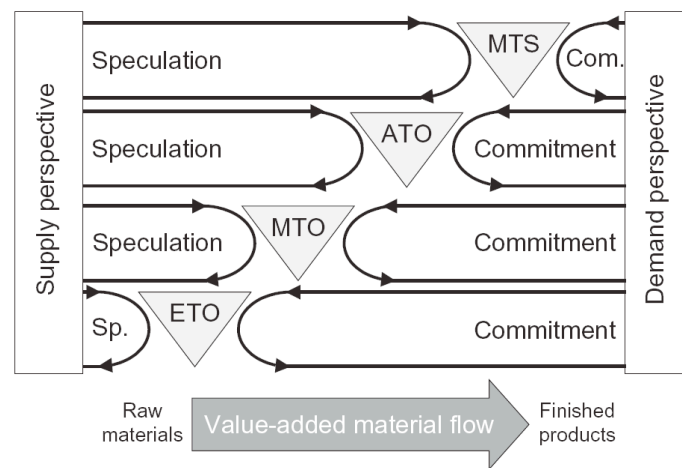


Figure 1. Approach to the CODP (Rudberg and Wikner, 2004)

Wikner and Rudberg (2001) note that most literature does not distinguish between engineering and production related activities. To provide a more nuanced picture than this traditional distinction, Rudberg and Wikner (2004) suggest that the CODP is both seen in an engineering dimension (ED) and a production dimension (PD). In the engineering dimension they define ETO_{ED} (Engineer-To-Order), ATO_{ED} (Adapt-To-Order) and ETS_{ED} (Engineer-To-Stock), and in the production dimension they define MTO_{PD} (Make-To-Order), ATO_{PD} (Assemble-To-Order) and MTS_{PD} (Make-To-Stock). According to Wikner and Rudberg (2004), from this perspective what is traditionally defined as ETO can be seen as including ETO_{ED} and MTO_{PD} , MTO as including ETS_{ED} and MTO_{PD} , ATO as including ETS_{ED} and ATO_{PD} , and MTS as including ETS_{ED} and MTS_{PD} . ATO_{ED} combined with MTO_{PD} or ATO_{PD} can from an engineering perspective be seen as being placed between traditional ETO and MTO.

The described two-dimensional distinction between CODPs illustrates that ETO in the purest form differs from other three overall strategies in that the engineering work has to be done for each order, while for the other strategies the engineering work have already been carried out, i.e. the product design is in principle in stock before a customer order (Rudberg and Wikner, 2004). While ETO represents pure customization and MTS is the approach of mass producers, ATO and MTO are approaches that support a mass customization strategy.

Definitions of mass customization

Naturally, the first definition of mass customization to appear was proposed by the creator of the term, Davis (1987), who defines mass customization as when "the same large number of customers can be reached as in mass markets of the industrial economy, and simultaneously they can be treated individually as in the customised markets of pre-industrial economies" (Davis, 1987). Later, Pine (1993) made an important contribution to the mass customization literature with his book "Mass Customization: The new frontier in Business Competition". In this book Pine defines mass customization as "to provide tremendous variety, and individual customization, at prices comparable to standard goods and services". Another early definition of mass customization is made by Hart (1995), who actually presents two definitions - a visionary definition: "the ability to provide your customers with anything they want profitably, any time they want it, anywhere they want it, any way they want it", and a practical definition: "the use of flexible processes and organizational structures to produce varied and often individually customized products and services at the low cost of a standardized, mass-production system". Although such definitions seem to be rooted in a transition from mass production, not only mass producers can become mass customers according to Pine et al. (1995), who describe how the company Ross Controls from the custom industry, by using CAD and CNC technology together with specialized sales personnel became able to mass customize.

Other later and popular definitions also seem to be rooted in mass production, as exemplified by Tseng and Jiao (2001): "to deliver goods and services that meet individual customers' needs with near mass production efficiency". This definition does not necessarily exclude the movement from ETO to mass customization. Still, this depends on whether it is reasonable to label companies in which only parts of the products are produced at near mass production efficiency as mass customizers, and depending on what can be labelled as services. This discussion is in focus later in this paper.

Another more recent definition has been proposed by Silveira et al. (2001), who defines mass customization as relating to "the ability to provide customized products or services through flexible processes in high volumes and at reasonably low costs". While this definition may convey the mass customization ideal, it is less than useful when analysing ETO companies whose products are not produced in high volumes. It is also not possible to evaluate the cost component for ETO companies as the products are qualitatively different and not readily comparable.

Piller (2004) presents a definition of mass customization that offers a higher level of detail than most other definitions, namely: "Customer co-design process of products and services, which meet the needs of each individual customer with regard to certain product features. All operations are performed within a fixed solution space, characterized by stable but still flexible and responsive processes. As a result, the costs associated with customization allow for a price level that does not imply a switch in an upper market segment". The objective of the article by Piller is to analyse the recent state of mass customization practice by answering the four basic questions of: "Do customers need customized products?", "If yes, what prevents them from purchasing these offerings?", "Do we have the enabling technologies for mass customization?", and "why do many firms fail during and after the introduction of mass customization?" To answer these questions, Piller makes twelve propositions about mass customization. Piller focuses his discussion on companies that are serving typical "mass" markets, conventionally characterized by made-to-stock and inventory-based distribution systems. For this reason some of Piller's propositions exclude movements from ETO to mass customization. This is exemplified in Piller's proposition 8, in which customers face risks directly from the customization process. However, in a scenario where an ETO company moves towards mass customization, customers are already facing this risk, and moving towards mass customization, if anything, only minimizes the risk. Similar argument applies to proposition 9, in which mass customizers need to prevent "mass confusion", which again is not the case when an ETO company moves towards mass customization, because the solution space is reduced.

The change towards customization

According to Lampel and Mintzberg (1996) the right degree of customization is dependent on the kind of industry a company is part of. They mention two extremes, "mass industries" (manufacturing standardised goods, often in large volumes) and "thin industries" (large degree of customization, often in low volumes). They argue that an important consequence of the shift to what they refer to as "customized standardization" of companies at both ends of the continuum means that customers lose flexibility in one area and gain flexibility in the other area. Hereby, they point out an important distinction between mass production and ETO companies that move towards mass customization, i.e. mass producers increase product variety and ETO companies decrease product variety.

Gilmore and Pine (1997) identify four distinct approaches to customization, where more than one of these can be applied at the same time: collaborative (dialogue with individual customers to help them articulate their needs, and to make customized products for them); adaptive (offer one standard, but a customizable product that users can alter themselves); cosmetic (present a standard product differently to different customers); and transparent (provide unique goods/services without telling customers explicitly about the customization). Both mass production and ETO companies that move towards mass customization would normally be categorised as "collaborative". However, when ETO companies move from pure customization towards mass customization this would often be more transparent than when mass production companies move to mass customization. When mass production companies move to mass customization the goal is often to provide more options for the customer, for which reason these options are made very visible to the customer. ETO companies that move towards mass customization have taken a different approach focusing on optimizing internal processes (Hvam, 2004; Hvam, 2006; Petersen and Jørgensen, 2005; Steger-Jensen and Svensson, 2004; Hansen et al., 2003). Since customers of ETO products expect to get products tailored to their needs, the use of a predefined solution space in which the customization takes place may not be communicated to the customers. Similarly, in some cases the movement from ETO towards mass customization is supported by a configurator, enabling the company to produce quotes much faster than normal. However, presenting a quote very rapidly could by some customers be perceived as lack of seriousness, why some companies may pretend that specification tasks take more time than they actually do. In such cases the standardization may, therefore, not be very visible to the customer.

Duray et al. (2000) propose a mass customization typology that describes four different approaches to implementing a mass customization capability. The typology is based on the presumption that mass customizers can be identified and classified based on two characteristics: i) the point in the production cycle when the customer gets involved in the specification of the product, and ii) the type of product modularity employed. This forms a matrix describing four archetypes: 1) Fabricators, 2) Involvers, 3) Modularizers, and 4) Assemblers. Although the matrix outlines different approaches to mass customization, it does not provide a distinction between mass customizers that are coming from mass production or ETO, since these two types of companies, at least in principle, both can be of any and all of the mentioned four types. Duray et al. (2000) do not mention ETO companies, but distinguish between customized crafted products and standardized mass produced products. Furthermore, Duray (2002) makes three propositions, which are supported by data from 126 mass customizers: 1) Companies practicing mass customization produce non-mass customized products, either standard or custom, in the same plant; 2) Standard and custom product manufacturers adopt distinctly different approaches to mass customization; 3) Companies that adopt approaches to mass customization that most closely resembles the non-mass customized products of the plant will exhibit higher financial performance. Addressing proposition 2, the findings of Duray show that standard producers have higher representation in what she calls Modularizers and Assemblers, while companies which produce more than 50 percent of their products as customized have higher representation in what she calls Fabricators (Designers) and Involvers, i.e. an earlier point of customer involvement.

Although some of the described literature indicates or claims that a move from ETO to mass customization is possible, this review also illustrates that definitions of mass customization most often seems to be rooted in a move from mass production to mass customization. Thus, it is unclear from which perspective ETO companies who automate part of their specification process can be labelled as mass customizers. Before answering this question, the basis is enhanced by comparing the motivations, risks and transitions to mass customization for mass producers and ETO companies.

The motivation and risks of moving to mass customization

The motivation for an ETO company to move towards mass customization can be based on different factors. If we return to the distinction between an engineering dimension and a production dimension (Rudberg and Wikner, 2004), an ETO company that moves towards mass customization would need to standardize their engineering work, i.e. approaching an ETS_{ED} state by defining parts of the solution space before receiving specific customer requirements. This kind of approach implies a postponement of the CODP, which can lead to benefits such as: reduced delivery times, more precise cost calculations, reduced specification costs, less training needed training for new sales personal etc. From a production point of view, the increased standardisation of the customized products can lead to benefits, such as reductions of manufacturing costs and amount of errors. However, the transition is not risk-free. An essential challenge in this transition from ETO towards mass customization is to find the right balance between flexibility and standardization. Not in all cases adequate standardization can be achieved while still being able to satisfy an adequate amount of customer demands, i.e., if not a certain degree of commonality between the required product designs exists. Furthermore, moving towards mass customization for an ETO company implies a simplification of the product designs offered. This aspect can have unfortunate consequences, since it may lead to problems such as: loss of innovative capability, greater chance of imitation by competitors, and organisational resistance as a consequence of simplifying/trivializing the engineering work (Edwards et al., 2005). Also the resources needed for the creation of this predefined solution space should be considered in relation to the potential amount of customers. If the products are very complex, the costs of a standardization project could turn out to be too high for the move towards mass customization to be profitable.

For mass producer, the move towards mass customization is in many respects opposite to ETO companies. When producing to stock the amount of products produced is often based on forecasts, and by moving to a MTO approach, the dangers of imprecise forecasts will be reduced. However, to avoid long response times, sufficient safety stock would be needed, for which reason the danger of not being able to sell purchased items still exists, but in a smaller scale. Another motivation for a mass producer to move to mass customization is to become better at satisfying requirements of certain customers in order to reach new marked segments or achieve a competitive advantage. But, for a mass producer to move to mass customization also possesses some risks, such as the in literature mentioned phenomenon of "mass confusion" (Piller et al., 2005), i.e. that customers feel that the choices is a burden and choose standard products instead. Also, from a production perspective, when a mass producer moves to mass customization, the manufacturing process becomes less standardized and errors more likely to occur. Furthermore, distribution of products becomes more difficult, as more direct communication with customers becomes necessary.

The transition towards mass customization

The described motivations and risks associated with the move towards mass customization for ETO companies and mass producers respectively showed great dissimilarity. To further illustrate this aspect, five general characteristics unfolding the differences in the two paths to mass customization are described. The five characteristics

are: (i) product variety, (ii) customer view, (iii) manufacturing costs, (iv) business purpose, and (v) configurator challenge. While other characteristics may be identified, our purpose here is merely to illustrate important differences between the two paths to mass customization.

1) Product variety: For mass producers to move to mass customization requires that the customers are now allowed to choose different product components or properties, before the product is delivered. On the other hand, an ETO company normally creates a new product for each order, and the challenge when moving to mass customization is to predefine the elements of which the new products can consist, which, obviously, limits the options for the customer. In short, mass producers have the task of encouraging product variety while ETO companies have the task of limiting product variety

2) Customer view: When moving from mass production to mass customization, from the customer's point of view, the increased influence on the design of the product has to have a value, otherwise the possible choices are just confusing or annoying. On the other hand, when an ETO company moves towards mass customization, the creation of a predefined product solution space, obviously, involves the risk that the solution space is not adequately large in order to satisfy the requirements of all customers.

3) Manufacturing costs: In this context manufacturing costs refer to all costs associated to fulfilling an order, including engineering design. Moving from mass production to mass customization implies that the manufacturing task becomes more complex by requiring more planning, a more flexible manufacturing process etc. However, when such tasks can be limited, product prices close to the ones of mass production can be achieved, i.e. what most define as mass customization. Obviously, the opposite is the case when an ETO company moves towards mass customization, in that this implies simplification of the manufacturing process and lower costs per manufactured product.

4) Business purpose: The normal incentive for moving from mass production to mass customization is to make the products offered more attractive to the customers in order to generate or increase sales. In order to be a mass customizer (according to many definitions) the prices of the mass customized products must be close to mass produced ones, which means that if sales are not increased, the investment in becoming a mass customizer would not be returned. As mentioned, it seems that the most important indictment of ETO companies that move towards mass customization is to automate some internal processes. But although an increase of sales is not the main purpose, the effects of the optimisation could have a sales-increasing effect, i.e. from shorter delivery times, more customer involvement in the design process, being able to manufacture faster etc.

5) Configurator challenge: The design choices of the customers in a scenario where a mass production company becomes mass customizer are normally limited compared to an ETO company that becomes a standardized customizer, and since the focus of mass producers that become mass customizers typically is to increase sales, the user-interface of web-configurators becomes of the highest importance (Rogoll and Piller, 2004; Piller, 2004). On the other hand, ETO products are often hard to standardize to a degree that allows configuration, for which reason the knowledge-base design generally is one of the main challenges, when creating a configurator for an ETO company that becomes a standardized customizer (Sabin and Weigel, 1998; Hansen et al., 2003; Edwards and Ladeby, 2005).

The five characteristics described are summed up in figure 2.

General characteristics of transition towards mass customization		
	Mass Production to Mass Customization	Engineering To Order to Mass Customization
1) Product variety	Increase variety	Limit variety
2) Customer view	Create valuable variety	Create adequate variety
3) Manufacturing costs	Slight increase	Decrease
4) Business purpose	Increase sales	Optimise processes
5) Configurator challenge	User interfaces	Knowledge base

Figure 2. Two paths to mass customization

Besides the difference in characteristics of the transition towards mass the efforts associated with the product redesign differ. Mass producers that move towards mass customization deal with much simpler products than ETO companies and their basis is in a standard product, i.e. all components in the products are standardised. Thus, for mass producers, mass customization can be achieved by minor product design changes, such as allowing that some components can be interchanged with others (e.g. the same component in different colours) or by offering addable components. On the other hand, for ETO companies the basis is in products that does not consist of only standardised components (if so, such a company would from a production perspective be classified as ATO), and a full standardisation may not be possible if to satisfy customer requirements. Therefore, from a product design point of view, a transition to mass customization seems generally to be much more complex for an ETO company compared to a mass producer.

Do ETO companies really become mass customizers?

If being a mass customizer requires the ability to produce products at prices close to mass produced ones, at least in theory, ETO companies can become mass customizers. For an ETO to be come mass customizer according to the common definitions would imply that the engineering work becomes more standardised, i.e. approaching an ETS_{ED} state by predefining a solution space in where customized products can be configured. This, however, would require radical changes e.g. in the form of limiting the product variance, automating the engineering tasks by use of knowledge-based systems, and improvement of manufacturing techniques. The question is whether this is actually what happens when ETO companies are described as mass customizers in literature?

Most literature claiming that ETO companies become mass customizers has a main focus on technology and does not in a detailed manner deal with the business-oriented impact of the mass customization projects (e.g. Hvam, 2004, Hvam, 2006, Petersen and Jørgensen, 2005, Edwards and Ladeby, 2005, Steger-Jensen and Svensson, 2004; Hansen et al., 2003). This literature does, therefore, not report whether or not product prices near prices of mass produced products have been achieved. However, the studies to some degree indicate that this is not the case even if product prices may be reduced from the automation of some of the specification tasks. Therefore, it seems that most of such ETO companies do not become true mass customizers in the sense that they are capable of producing customized products at prices close to standard products. The question is: should these ETO companies be labelled as something else or should the traditional definitions be redefined?

In the mass customization cases of Adidas (Moser et al. 2006), Swatch Via Della Spiga (Pillar et. al, 2005) and Lego (Pillar et. al, 2005) only a small part of the product portfolio can be customized by the customer. By relating the example of mass customizing only a small part of the product portfolio to the engineering design processes

at ETO companies some interesting conclusions can be made. By dividing the entire design process of an ETO product up into small work packages, it may be possible to completely automate some of them. This would require a predefined solution space and a consistent specification process that allows for involvement of the customer in the design process, but is actually what companies like F.L. Smidth and GEA Niro do (e.g. Hvam, 2004). Therefore, part of the price of creating the product may be at prices near prices of mass produced products, which implies that at least these products could be labelled as being partly mass customizable.

The main focus of the configuration projects at for instance F.L. Smidth and GEA Niro has been on the creation of quotes. Whereas the detailed design processes to a great degree is still carried out by engineers in a traditional manner, the creation of quotations based on customer inputs is more or less completely automated by a product configurator. The quote can be seen as a service or a product that can be produced at a cost that is near the one of letting a customer choose between different standard solutions. From this perspective it seems reasonable to label these processes as mass customization processes. Perceiving product specifications as a mass customizable product is supported by the fact that some of these kinds of companies do not manufacture the specified products themselves, but only provide the product specifications. Therefore, mass customization may be seen from different perspectives: characteristics of the products, i.e. can mass customized products be produced at prices close to mass produced ones, and a process perspective, i.e. can parts of the engineering design process be automated and thereby cost-wise comparable to a mass production approach.

Piller (2004) incisively states that mass customization has become a buzzword, where a major problem is that there is no clear definition and common understanding of the term. Furthermore, Piller points out that if not a common agreement on a definition or understanding of mass customization is reached there is a risk that the field of mass customization will become neither an academic discipline nor a broad strategic concept that is recognized by managers. To help avoid dilution of the concept of mass customization while not excluding ETO companies, an emphasis should be made on the importance of making a clear distinction between mass customizers that comes from mass production and custom production without ruling out any of these two kinds of movements. First, this requires a mass customization definition that is broad enough to include both kinds of movements, i.e., a definition with lesser focus on having product prices close to the prices of mass produced products (or to avoid a movement to an upper marked segment). Second, there is a need for clear definitions and understanding of different sub-types of mass customizers, for which reason the basic definition of mass customization could be extended by definitions of different kinds of mass customizers. Such sub-definitions of mass customization could in the case of mass producers and ETO producers be something like: "Typically, the incentive for mass producers to become mass customizers is to allow a customer co-design process while keeping the costs of products comparable to the ones of mass produced, while the incentive for custom producers for pursuing a mass customization strategy is to optimize internal processes by defining fixed solution space in where the customer co-design can take place".

Conclusions

Most mass customization literature deals with mass producers that move to mass customization. However, some literature deals with another kind of movement, namely when ETO companies moves towards mass customization. This paper pointed out that when ETO companies moves towards mass customization, these do not necessarily become mass customizers in the sense that these are capable of producing products at prices close to if such products had been mass produced. For an ETO company to become a mass customizer the challenge is to move the time of differentiation closer to the time of delivery, i.e. postponement. From an engineering point of view this means to increase the predefined part of the engineering work and from a production perspective to a

greater degree to be able to assemble to order instead of manufacturing new components for each order. In other word, what ETO companies need to do is to move from an ETO_{ED} combined with MTO_{PD} approach and towards an ETS_{ED} combined with ATO_{PD} approach. However, based on the ETO related mass customization cases described in literature, such companies do not seem to fully achieve this transition, although they by standardising their products may be able to deliver customized products at prices lower than traditional ETO companies, and from a product price perspective, be placed somewhere in between ETO and mass customization. It does therefore not seem that ETO companies that move towards mass customization should be labelled as mass customizers from the same perspective as mass customizers originating from mass production.

This paper offers an alternative perspective on what mass customization can be by arguing that since being a mass customizer does not rule out that the company also creates mass produced products, for ETO companies, instead of a part of the product portfolio, the focus may be on the parts of the products that can be mass customized. In other words, maybe some of the engineering design processes associated with the specification of a product can be automated. This pattern can be found in some ETO companies where only some of the product solution space is predefined (i.e. the choices in the early design phases), while detailed design decisions do not take place within a predefined solution space. Since part of the production can be seen as mass customized, such companies can at least be labelled as partly mass customizers. Another suggestion of the paper is that companies could be labelled as mass customizers even if these are not capable of providing customized end-products at prices similar to if these had been mass produced, but on the other hand, if, by the use of standardisation and configuration technology, they are capable of delivering customized product specifications (such as quotes) at costs close to delivering standard specifications. In this context an important observation is that some ETO companies do not manufacture the physical product themselves, but only create product specifications, which is, therefore, their product.

Therefore, if to avoid a definition of mass customization that excludes one of the mentioned categories of companies, this paper proposes that future mass customization research defines mass customization on two abstraction levels. Firstly mass customization should be defined in a broad sense that does not exclude or indicate that other movements than the one from mass production is possible. Secondly, this definition should be extended by more specific sub-definitions of different kinds of mass customizers. The need of such separate definitions of mass customizers is illustrated in this paper by describing some of the important differences in the characteristics of the transitions for mass producers and ETO companies that move towards mass customization, i.e.: if the product variety increases or decreases; if the challenge is to provide valuable or adequate product variety; if the total costs of manufacturing a product increase or decrease; if the main business purpose of the project is to increase sales or optimise internal processes; and if the main configurator challenge is to create user interfaces or the knowledge base of the product configurator.

All in all, it is the hope that this paper can contribute to the creation of a common definition and understanding of mass customization, which is a task that still seems to require much research and discussions.

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